Explore the effect of semi-active fuzzy control of MR damper on vibration reduction

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Abstract

According to the principle of structural vibration fuzzy control, an analytical model of a 20-story semi-active control MR damper is established, and the solving software is programmed by using MATLAB language. The results show that the semi-active MR damper control can achieve the target vibration reduction effect by adjusting its parameter index fdmax. The larger the fdmax is, the higher the efficiency of dynamic response of interstory displacement and floor displacement is, and the larger the amplitude of semi-active control force is. The efficiency of shock absorption can reach 30-50%, and the efficiency of shock absorption is evenly distributed along the height of the building.

Keywords

Semi-active control; Fuzzy mode control; Seismic dynamic response.

1. Introduction

Semi-active control of structural vibration combines the advantages of active control and passive control. Only a small amount of energy regulation is needed to achieve the active optimal control force as far as possible. Hiwatashi .T[1] The performance of MR damper for isolation structure is studied comprehensively. Shaking table test of three-story large frame isolation structure is introduced. The test results verify the control system and control effect of MR damper as a semi-active device. U.Aldemir[2] The optimal control performance of MR dampers is studied. The MR dampers are applied to single-degree-of-freedom systems and various forms of dynamic loads are applied. At present, the research results of artificial intelligence such as fuzzy logic, neural network and evolutionary computation have been applied in the field of structural vibration control.

2. Brief Introduction of Fuzzy Control Principle

The research goal of fuzzy control is not the controlled object but the controller itself, so it is not necessary to establish an exact model of the controlled object [3]. The fuzzy control rules are an important part of the fuzzy controller.

3. Computational examples and results

In order to analyze the semi-active damping effect of MR dampers for multi-degree-of-freedom structural systems, a 20-story structural system model is established and simplified. The calculation models are mi=2933t, ki=28950000KN/m and ci=22000KN.s/m. MR dampers are installed on each floor. The seismic wave of Shanghai artificial wave 5 is used. The maximum horizontal ground acceleration is 4.0m/s2 and the earthquake intensity is 8 degrees. After analysis and calculation, the dynamic responses of three seismic reduction schemes under earthquake action and MR damper are shown in Tables 1 and 3-9.

3.1.1 A Brief Introduction to Seismic Waves

The time interval of Shanghai-hai artificial wave 1 is 0.02s, the total time is 24.9 seconds, the total number of points is N=1246, and the maximum acceleration peak is 35 cm/s 2. Suitable for type IV site soil. When calculating the data, the peak acceleration is adjusted to 4m/s2.

3.1.2 Analysis of calculation results

Shanghai artificial wave 5 is input into the program. According to the predicted results of the dynamic response equation of the structure, the vibration reduction effect of the modal fuzzy control is evaluated.

Table1 Comparison of displacement damping efficiency between three algorithms

floor	story drift（AMD） /mm	damping efficiency /%	story drift （fuzzy） /mm	damping efficiency /%	story drift （uncontrolled）/mm
0-1	5.9337	59.52	10.2069	59.52	25.2174
1-2	5.927	59.21	10.1755	59.21	24.9467
2-3	5.924	58.56	10.1041	58.56	24.3834
3-4	5.9133	57.82	9.9271	57.82	23.5375
4-5	5.8859	57.18	9.6	57.18	22.4213
5-6	5.8235	55.93	9.2794	55.93	21.0545
6-7	5.7169	54.64	8.9021	54.64	19.6233
7-8	5.5688	55.53	8.4537	55.53	19.0114
8-9	5.3874	56.27	8.0077	56.27	18.3117
9-10	5.1816	56.47	7.6134	56.47	17.4897
10-11	4.9563	57.27	7.0707	57.27	16.5458
11-12	4.7086	58.06	6.4875	58.06	15.469
12-13	4.427	59.01	5.9158	59.01	14.4307
13-14	4.0933	60.60	5.277	60.60	13.3926
14-15	3.6887	61.30	4.6804	61.30	12.0941
15-16	3.2259	62.24	3.9813	62.24	10.5425
16-17	2.682	63.30	3.213	63.30	8.7556
17-18	2.0771	66.05	2.2962	66.05	6.7627
18-19	1.4185	65.04	1.61	65.04	4.6048
19-20	0.7195	63.05	0.8615	63.05	2.3318

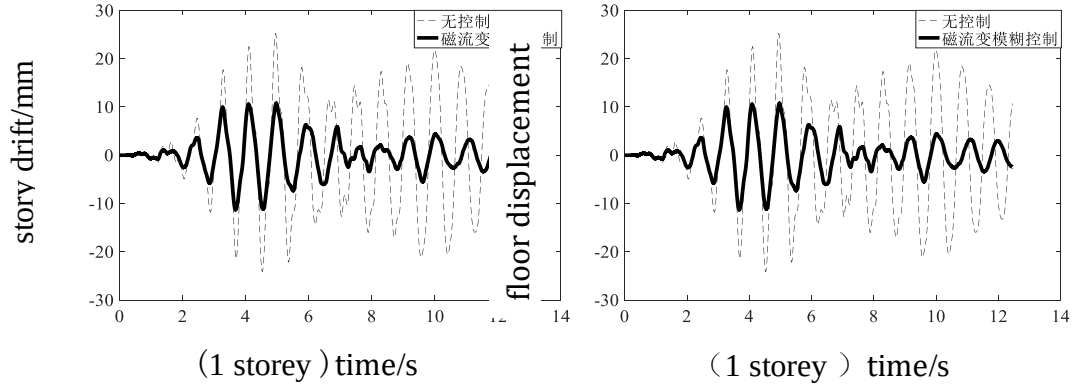
Compared with no control, for semi-active fuzzy control of MR dampers, it can be seen from table 1 that the effect of inter-story displacement vibration reduction is generally about 50%-70%, and the distribution along the height is more uniform, and the effect of vibration reduction is similar to that of AMD control.

Table2 Comparison of floor acceleration and damping efficiency of three algorithms

floor	floor acceleration （AMD） /m.s^{-2}	damping efficiency /%	floor acceleration （fuzzy） /m.s^{-2}	damping efficiency /%	floor cceleration（uncontrolled）/m.s^{-}

0-1	1.2058	62.89	16.1342	-396.59	3.249
1-2	2.1801	64.88	17.1725	-176.68	6.2067
2-3	2.9455	67.79	17.9852	-96.68	9.1443
3-4	3.6197	69.56	17.9413	-50.87	11.8917
4-5	4.1686	70.59	19.7096	-39.06	14.1736
5-6	4.5206	71.46	19.4343	-22.69	15.84
6-7	4.8038	71.66	19.9074	-17.44	16.9507
7-8	4.8974	72.92	19.7714	-9.33	18.0842
8-9	4.8166	74.29	19.6161	-4.70	18.7359
9-10	4.5836	75.47	20.7951	-11.29	18.6863
10-11	4.2992	76.01	21.2965	-18.86	17.9172
11-12	4.3058	73.88	21.9272	-32.99	16.4873
12-13	4.5351	72.74	21.6915	-30.39	16.6361
13-14	4.8395	72.58	22.5207	-27.58	17.6522
14-15	5.2012	71.69	22.0617	-20.06	18.3751
15-16	5.5709	71.39	23.977	-23.13	19.4728
16-17	5.9209	72.28	22.7813	-6.67	21.3578
17-18	6.2212	72.72	22.4624	1.50	22.8048
18-19	6.4389	72.92	22.8892	3.74	23.7788
19-20	6.5531	73.00	16.2151	33.18	24.2667

From Table 2, it can be seen that the effect of AMD control on floor acceleration is obvious; the semi-active fuzzy control algorithm of MR damper has almost no obvious effect, but it converges with the increase of floor.



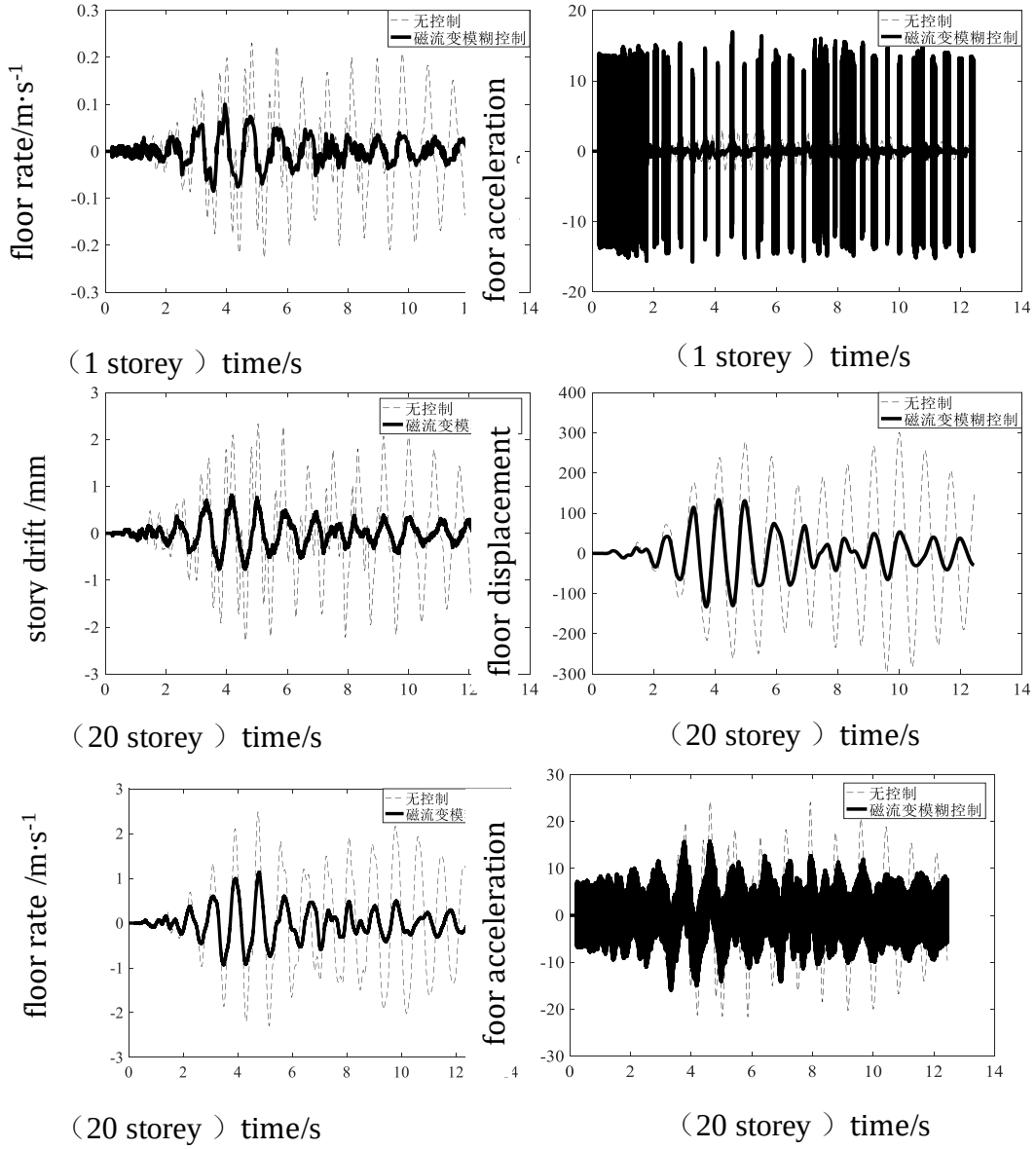
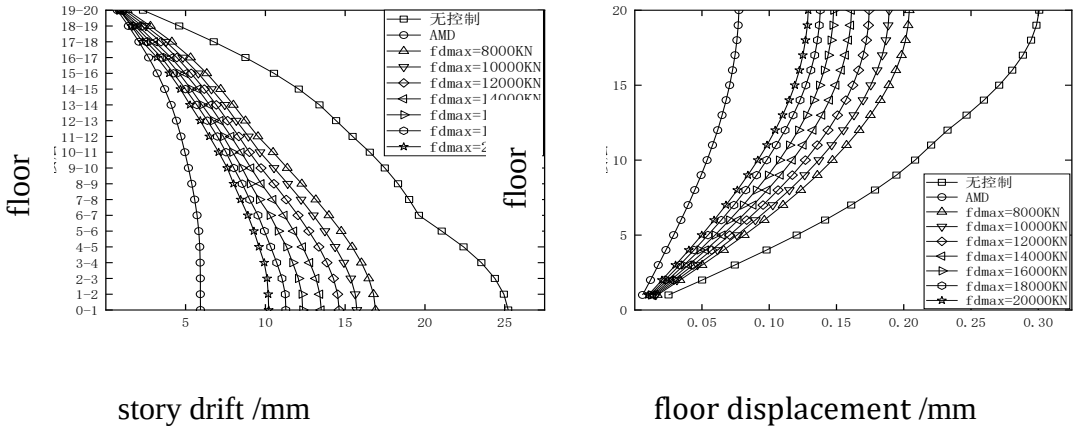


Fig.1 Time history of structural seismic dynamic response（*fd=20000KN*）



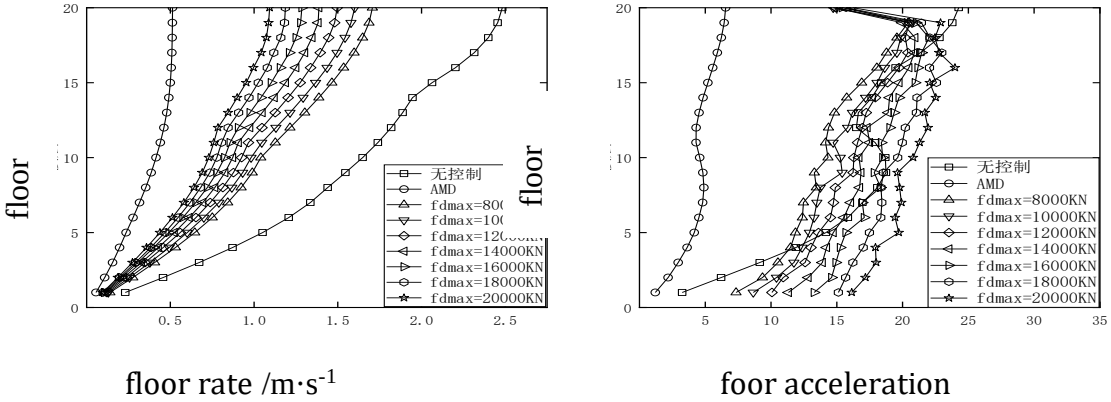


Fig.2 Structural seismic dynamic response

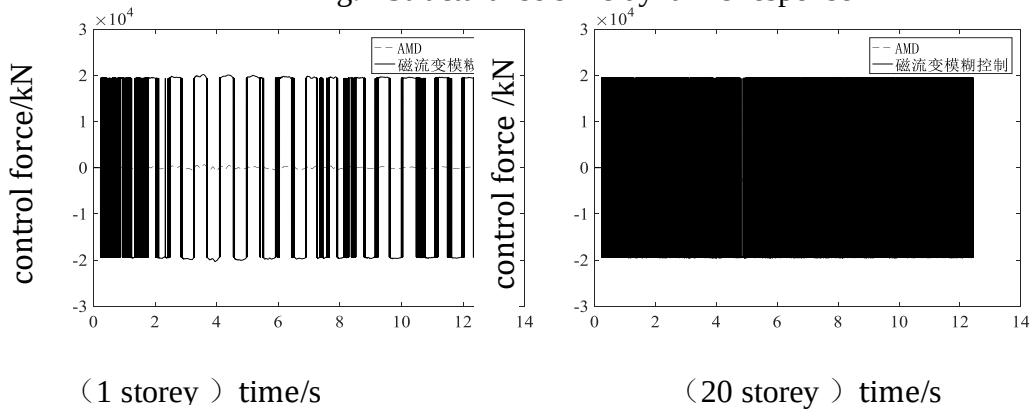


Fig.3 Fuzzy control force time history diagram

From Figure1, it can be seen that MR dampers based on semi-active fuzzy control have some control effects, such as inter-story displacement, floor displacement and floor velocity, which decay quickly with time, while floor acceleration decays slowly with time, and there is no obvious effect of vibration reduction. From Figure 2, it can be seen that the AMD optimal control has the best effect on the inter-story displacement, floor displacement and floor velocity. In contrast, the semi-active fuzzy control algorithm of MR damper has the best effect on the inter-story displacement, floor displacement and floor velocity in the seismic response map of structures. The larger the fdmax, the higher the seismic reduction efficiency is. The higher the floor acceleration, the greater the fdmax, the worse the shock absorption effect.

4. Conclusion

Semi-active fuzzy control of MR damper has obvious effect on inter-storey displacement, floor displacement and floor velocity. The maximum Coulomb damping force fdmax of adjusting parameter index achieves the target effect of vibration reduction. The dynamic response displacement of earthquake decreases rapidly with time, while the acceleration decreases slowly with time. But the semi-active control system needs less energy and is more economical and convenient. Under the same parameter index, the control force of semi-active fuzzy control is similar.

References

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